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NEWFIELDS, INC.

Pilot Project Work Plan

Waukegan Manufactured Gas and Coke Plant, Waukegan, Illinois

February 28, 2000

TABLE OF CONTENTS

1.0 INTRODUCTION

The Waukegan Manufactured Gas and Coke Plant (WCP) site is located in Waukegan, Illinois, on the peninsula separating Waukegan Harbor from Lake Michigan (Figure 1.1). The property and its environs have been part of the industrial/commercial waterfront in Waukegan. The sand dunes and beach area adjacent to the WCP Site are used for public recreation.

The WCP Site is underlain by near-surface fill materials that were placed over a fine-grained sand unit. The sand unit extends from the ground surface to the top of a low-permeability clayey till unit. The shallow groundwater occurs in a 30-foot-thick fine sand unit. Shallow groundwater flows in response to infiltration on the peninsula, discharging to the surrounding surface water.

The vadose zone soil and the deep portion of the shallow aquifer at the WCP Site have been adversely impacted due to past activities. Soil at the WCP Site is contaminated with tar and arsenic. The groundwater is mainly contaminated with arsenic, phenols, ammonia, benzene, cyanide, and thiocyanate. The impacted portion of the shallow aquifer is found in the lowest 5 feet of the sand unit, approximately 25 feet below ground surface. Figure 1.2 shows a plan view of the impacted portion of the shallow aquifer. This figure also shows the location of a beach transect. The vertical extent of arsenic and phenols in the shallow aquifer along the beach transect is illustrated in Figures 1.3 and 1.4.

Upon completion of the Remedial Investigation/Feasibility Study (RI/FS), the Record of Decision (ROD) for the WCP Site was issued in September 1999. The ROD defined six elements of the site groundwater remedy:

1. Short-term groundwater removal and on-site treatment/re-infiltration
2. Groundwater treatment
3. Waiver of the underground injection control prohibition
4. Long-term monitored natural attenuation
5. Long-term monitoring
6. Five-year reviews

The ROD groundwater remedial objectives are divided into two phases, as short-term (Phase 1) and long-term (Phase 2) goals. The short-term goal is a substantial reduction of contaminants at the deep portion of the shallow aquifer in order to remove the chemical inhibitors of natural attenuation. Subsequently in Phase 2, the long-term remedial goals are pursued based on Monitored Natural Attenuation. As noted in the ROD: "*Once the inhibitive concentrations of contaminants have been removed and the nitrate source and oxygenation from treatment re-injection is available in the aquifer, degradation should occur.*" In the long-term, attainment of maximum concentration limits (MCLs) is anticipated.

The ROD states that the design of the Phase 1 groundwater remedy will be based in part on pilot testing of a groundwater extraction and re-injection system. This Pilot Project Work Plan focuses on the Phase 1 elements of the groundwater remedy: (1) short-term groundwater removal and onsite treatment/re-infiltration, and (2) groundwater treatment.

This Pilot Project Work Plan is presented in nine sections, titled: (1) Introduction (this section); (2) Pilot Project Objectives and Data Needs; (3) Conceptual Approach; (4) Study Area Characterization; (5) Pilot Extraction and Re-injection Units; (6) Bench-Scale Groundwater Treatment Assessment; (7) Pilot Project Data Analysis Goals; (8) Pilot Project Report Outline; and (9) Pilot Project Schedule. More detailed information concerning the WCP Site characterization and alternative remedies are provided in the RI/FS (Barr, 1995 and 1998).

2.0 PILOT PROJECT OBJECTIVES AND DATA NEEDS

As stated in the ROD, the design and implementation of the selected groundwater remedy (i.e., the mobile, cell-based, low-flow extraction/treatment/re-injection system) will be based on the current RI/FS data, the pre-design investigation, and pilot testing. Consistent with the ROD framework, the objective of this Pilot Project is to determine design parameters and constraints for implementation, operation, and performance measurement of an extraction/re-injection unit of the ROD groundwater remedy.

To attain the objective of the Pilot Project, the following data needs must be met:

A. ***Pilot Study Area Characterization:*** Characterization of the pilot study area is needed to allow extrapolation of the pilot study results over the entire site. For this purpose, the lateral and vertical extents of the groundwater contaminants of concern in the study area will be adequately determined. This data need will be addressed with direct-push probe profiles and data from monitoring wells installed as a component of the extraction pilot testing.

B. ***Hydrogeologic Constraints to Mass Removal/Re-injection:*** The effectiveness of the extraction/re-injection units will be constrained by the hydrogeologic and geochemical characteristics of the impacted portion of the shallow aquifer. During the Pilot Project, these constraints will be determined through direct monitoring of the performance of the pilot units. For this purpose, pilot units will be operated under a variety of scenarios, such as: (1) constant low-flow extraction/re-injection; (2) intermittent (pulse) low-flow extraction; and (3) variable extraction rates. A tracer test will also be conducted during the constant low-flow extraction/re-injection test to better characterize the groundwater flow regime during the operation of the pilot units. Throughout these pilot testing activities, multi-depth groundwater samples will be collected on a regular basis. The resulting data will provide key information on mass removal rates and trends under various extraction scenarios, as well as groundwater flow-regime under low-flow extraction/re-injection process. The analyses of collected data will form the foundation of the design and operation of the field-scale extraction/re-injection units.

C. ***Treatment Constraints/Natural Attenuation Threshold Criteria:*** The ROD groundwater remedy calls for the treatment of the extracted water prior to its re-injection into the deep portion of the shallow aquifer. This treatment is aimed at achieving a two-faceted goal - treating the extracted water for contaminant removal, while yielding geochemical properties to enhance the natural attenuation of the impacted groundwater. As the ROD states, upon completion of the extraction/re-injection phase of the remedy, the long-term groundwater remedial goals will be attained through natural attenuation. Therefore, during the Pilot Project, representative extracted water samples will be the subject of a bench scale treatability study. The bench scale is designed to determine: (1) contaminant removal effectiveness and the limitations of various alternative treatment processes and trains; and (2) the impact of the extraction/re-injection process on reduction of contaminant concentrations at the deep portion of the shallow aquifer. This pilot information, along with previous site-specific experimental and numerical results, may also provide a basis to define the in-situ threshold contaminant concentrations and/or loads within the deep portion of the shallow aquifer beyond which ROD long-term remediation objectives can be attained through natural attenuation.

To address the above Pilot Project objective and data needs, a pilot testing system is proposed. The conceptual aspects of the proposed system are described in the following section.

3.0 CONCEPTUAL APPROACH

The data needs of this Pilot Project require operation of the system under a variety of scenarios. For this purpose, a two-unit system is proposed, as depicted in Figure 3.1. Components of this system are:

A. ***Extraction/Re-injection Unit (E/R Unit):*** This unit is composed of three extraction wells and six re-injection wells. This unit is intended to simulate the simultaneous operation of low-flow extraction and re-injection wells. In such units, the outer re-injection wells are intended to supply flushing water that may enhance the removal efficiency of the inner extraction wells. The E/R Unit will be operated at a constant extraction rate for the duration of the pilot testing period. During the Pilot Project, tap water will be used for re-injection. Periodically during the operation of the E/R Unit, the tap water will be sampled for pH, chlorine, and dissolved oxygen to verify the quality of the injected water and assess any impacts on the re-injection process.

B. ***Extraction Unit (E Unit):*** This unit is composed of a single extraction well, which will be operated under both steady state and pulse conditions with up to three different extraction rates. The data from this unit, as well as the E/R Unit, will provide a comparative basis to determine effective extraction/re-injection operation patterns, rates, and scheduling. Specifically, removal efficiency of extraction wells will be evaluated under constant versus intermittent (pulse) operation, as well as different extraction rates.

C. ***Equalization Tanks:*** As depicted in Figure 3.1, the extracted water from both units will be stored in three 20,000-gallon Equalization Tanks. These tanks will be used to provide short-term storage for the extracted water during the Pilot Project, and may be used for quality/flow equalization during the operation of the full-scale treatment system. If used during the operation of the full-scale system, the tanks would enhance the effectiveness of the system by equalizing wide concentration variations during operation of an extraction/re-injection cell. The Equalization Tanks can also serve as separators in the event of observing non-aqueous phase liquids in the extracted water. The treatability study will be conducted based on water samples from the Equalization Tanks. The remaining water stored in these tanks is intended to be either used as influent for the initial start-up operation of the future onsite treatment system, or disposed of offsite.

More detailed information concerning the elements of the pilot study is provided in the following sections.

4.0 STUDY AREA CHARACTERIZATION

The pilot study area is shown in Figure 1.2. Further details about the configuration of Units within the study area are provided in Section 5.1. Characterization of the study area will be conducted the following testing:

1. At least, two direct-push or GeoProbe vertical geophysical profiles will be collected to estimate the vertical extent of the impacted portion of the shallow aquifer. Geophysical profiles will be collected close to the center of each Unit using Cone Penetrometry Gas Chromatography. This technology will be used to create a profile of both the bulk organic contaminant concentration and the bulk density of the soil with depth.
2. Groundwater samples from the deep portion of shallow aquifer will be collected from the extraction and re-injection wells prior to initiation of the testing . Proposed sample analyses are described in Section 5.3.
3. Mult-depth groundwater samples will be collected at two installed monitoring well nests associated with the E/R Unit and at one installed monitoring well nest associated with the E Unit. These clustered wells will be installed using the micro-well or direct-push technology. Proposed sample analyses are described in Section 5.3.

5.0 PILOT EXTRACTION AND RE-INJECTION UNITS

5.1 PHYSICAL DESCRIPTION

Consistent with the findings of the FS (Barr, 1998) and the ROD-selected short-term remedy, two groundwater extraction units will be installed during the Pilot Project, denoted as the E/R and E Units. The E/R Unit will consist of nine wells laid out in three parallel rows with one extraction well and two re-injection wells in each row. A plan view of the E/R Unit is shown in Figure 5.1. A transect across the E/R row at the center of the E/R Unit is shown in Figure 5.2. Each extraction well will be screened in the bottom 5 feet of the shallow aquifer. The re-injection wells will be screened in the bottom 5 to 10 feet of the shallow aquifer, depending on the thickness of the impacted portion of the aquifer. Water extracted from the inner three extraction wells will be stored in onsite Equalization Tanks. Tap water will be re-injected in the outer six wells. During the pilot testing, the E/R Unit wells will be operated at constant extraction and re-injection rates of approximately 0.3 gallons per minute (gpm) and 0.15 gpm per well, respectively. The wells will be controlled individually to balance extraction and injection flows among the wells.

The second test unit (the E Unit) will consist of a single extraction well screened in the bottom 5 feet of the shallow aquifer. Similar to the E/R Unit, the extracted groundwater from this unit will be stored in onsite Equalization Tanks. The E Unit will be operated intermittently at variable extraction rates, as discussed in the following subsection.

5.2 OPERATIONAL DESCRIPTION

Consistent with the ROD-selected short-term remedy, based on a low-flow, cell-based extraction/re-injection system, the E/R Unit will be pumped at a constant low-flow rate of approximately 0.9 gpm (i.e., 0.3 gpm from each extraction well) for approximately 4 weeks. Simultaneous with groundwater extraction, 0.9 gpm of tap water will be injected into the re-injection wells (i.e., 0.15 gpm into each re-injection well).

At the initiation of the operation of the E/R Unit, a bromide tracer test will be conducted. For this purpose, bromide will be added to the re-injected tap water upon commencement of operation of the central re-injection well closest to the monitoring well nest. Subsequently, groundwater samples will be analyzed from monitoring, extraction and re-injection wells to determine the path and rate of groundwater flow between the re-injection and extraction wells.

The E Unit will undergo an intermittent extraction schedule with the pump on for 7 days and then off for 7 days. Four cycles are contemplated for the pilot testing. The extraction rate from the E Unit will be reduced with each successive pumping cycle, starting at 0.8 gpm and ending at 0.2 gpm. The extraction schedule and rates for both units are presented in Table 5.1.

5.3 SYSTEM MONITORING

Groundwater quality will be monitored within the E/R Unit using two nests of five monitoring wells. A plan view of the monitoring well placement is shown in Figure 5.1. The multi-depth monitoring well nest 1 is located in a point that is expected to be highly affected by the flow generated by the operation of the extraction and re-injection wells. Nest 2, on the other hand, is situated between two extraction wells, which could create a nearly stagnant condition in the vicinity of this latter nest of monitoring wells. Therefore, the monitoring data from the two nests would provide information on the entire range of removal effects of the E/R Unit.

Each monitoring well will be screened over an interval not to exceed 12 inches, as indicted in Figure 5.2. Groundwater quality in the vicinity of the E Unit will be monitored using a single nest of five monitoring wells, as shown on Figure 53. The nest of monitoring wells will be set approximately 5 ft from the E Unit well. These monitoring well nests will be installed using the micro-well or direct-push technology. All water samples will be collected with minimal purging[2]. The sampling technique to be used will entail inserting a small diameter tube down the monitoring well, purging only the volume of the tube, and then collecting the sample. This technique will minimize the effluence of the sample volume on in-situ contaminant concentrations. Collected groundwater samples will be routinely analyzed for field parameters, including pH, temperature, chloride, and dissolved oxygen. Groundwater levels may also be

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[1] Investigative-derived soil waste (e.g., drill cuttings) will be placed in drums. These drums will be disposed along with the RI/FS-related waste drums that are currently located onsite.
[2] Investigative-derived water waste (e.g., purged waters) will be placed in the Equalization Tanks.

measured as part of the Pilot Project monitoring efforts. The scopes of chemical analyses on each sample are presented in Table 5.2.

During the operation of the two Units the following sampling activities will be conducted:

1. ***Monitoring Wells***: Sampling and analysis of the monitoring wells within the E/R and E Units will be conducted according to the schedule specified in Table 5.2. In the E Unit, two of the scheduled samples each week will be drawn on the same day that the pump operational mode is changed (i.e., pumping started or stopped).
2. ***Tap Water Testing:*** Tap water, which will be re-injected during the operation of the E/R Unit will be periodically sampled and analyzed for pH, chlorine, and dissolved oxygen.
3. ***Tracer Test:*** Bromide tracer sampling of the monitoring wells within the E/R Unit will be conducted as specified in Table 5.2. Monitoring wells along with extraction and re-injection wells of the E/R Unit will be sampled daily for bromide for a period of 7 days. Bromide sampling will then shift to three times per week for the remainder of the E/R Unit test.
4. ***Extracted Water:*** Sampling of the extracted water from each extraction well of E/R and E Units will be conducted three times per week. The sampled water will be analyzed for the parameters identified in Table 5.2. In the E Unit, at least one sample each week will be drawn on the same day that that the pump operational mode is changed (i.e., pumping started or stopped). One sample will also be drawn at the midpoint of an operational mode.
5. ***Real Time Monitoring:*** Specific conductance of the outflow of the central extraction well of the E/R and E Units will be continuously monitored during the Pilot Project to monitor short-term variations in the quality of the extracted water.
6. ***Pilot Project Post-Extraction Monitoring:*** The extraction wells within the E/R and E Units will be sampled one week and one month after completion of testing to assess the rate of recovery of contaminants at the Pilot Project Units. The sampled water will be analyzed for parameters identified in Table 5.2.

Due to the frequency of the sampling, the advantages of minimizing sample volume, and the expected continuity in concentrations, duplicate samples are not needed in the above monitoring efforts. Upon availability of the above data, subsequent post-Pilot-Project monitoring may be planned and conducted to further assess the long-term effects of the low-flow extraction/re-injection system. All monitoring, extraction and re-injection wells that are deemed unnecessary for further sampling or full-scale implementation of cell-based remedy will be abandoned.

6.0 BENCH-SCALE GROUNDWATER TREATMENT ASSESSMENT

6.1 PROCESS WATER PRE-TREATMENT

Extracted water from the E Unit will be stored in 20,000-gallon tanks (i.e., the Equalization Tanks) onsite. Once a tank is filled, 75 gallons of the equalized groundwater will be drawn from the center of the tank. This water will be treated using the ANDCO[3] electro-chemical precipitation technology for arsenic removal using electro-chemical precipitation. The arsenic removal operating parameters will be based on the results of arsenic removal testing during the RI and the arsenic concentration in the process water. The treated water will be sampled to verify greater than 90% of the arsenic[4] is removed prior to shipping the treated water to a laboratory for biological treatment.

6.2 BENCH-SCALE BIOLOGICAL TREATMENT TESTING

The bench-scale biological treatment test will consist of at least two separate treatment trains, as described below:

1. The first treatment train will consist of two aerobic sequencing batch reactors (SBR) in series. The first SBR (SBR-1) will be operated to achieve biological degradation of organic compounds. The second SBR (SBR-2) will be operated to convert ammonia to nitrate (nitrification).
2. The second treatment train will consist of a single aerobic SBR (SBR-3) operated to achieve both organic removal and nitrification using the same sludge.

Additional treatment trains may also be considered.

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[3] ANDCO Environmental Processes, 595 Commerce Drive, Buffalo, NY 14228. Telephone: (716) 691-2100

[4] Final arsenic removal rate during the full-scale onsite treatment of extracted water will be determined based on site-specific data. For example, during the future natural attenuation study, as envisioned by the ROD, the effects of arsenic concentration on in-situ biodegradation will be addressed, which could lead to a different arsenic removal rate.

Seed sludge for each SBR will be obtained from a full-scale activated sludge treatment system that treats coke plant wastewater and achieves both biological organic removal and nitrification (e.g., US Steel-Gary Works). The influent to SBR-1 and SBR-3 will be the groundwater pre-treated for arsenic removal. The influent to SBR-2 will be the effluent from SBR-1.

During start-up, all of the SBRs will be operated on 6-hour cycles. The duration of each period within each cycle is presented in Table 6.1. The initial operating parameters for the SBRs are provided in Table 6.2. The values of these parameters are based on a pilot scale test of the biological treatment of coke plant wastewater (ref. Rupnow, Shelby, Singh, "Development of a New Wastewater Treatment System for a Major Coke Plant", Proc. Water Environment Federation 70th Annual Conference and Exposition, Chicago, Illinois, vol 3, part 2, pp. 265-276, 1997) . Each SBR will be operated continuously for four cycles each day for a minimum of one solids retention time (SRT). Table 6.3 presents the daily analysis to be accomplished during this acclimation phase. All daily analysis will be performed during the same cycle. At the end of this phase of testing, performance verification samples will be drawn for analyses, as presented in Table 6.4. These samples will be collected during one cycle each day for three consecutive days.

Once a SBR has operated for at least one SRT, the variation of parameters during a single cycle will be determined. During a single cycle of a SBR, the fill period (FILL) will be reduced to less than 5 minutes with no aeration. Once FILL is complete, the SBR will be mixed without aeration, and an initial sample will be collected. After sampling, the aerated react period (REACT) will start and the cycle will proceed using the operating strategy outlined in Table 6.1. The list of samples to be drawn and the analysis parameters for these batch time-based studies are presented in Table 6.5.

7.0 PILOT PROJECT DATA ANALYSIS GOALS

This section describes the goals of the analysis of the Pilot Project data. Graphical and statistical techniques will be employed to assess the variations in groundwater quality parameters during different phases of the Pilot Project. These analyses will be the basis for determining design parameters and constraints for implementation, operation, and performance measurement of extraction/re-injection cell units. These extraction/re-injection units constitute the short-term component of the ROD groundwater remedy.

7.1 HYDROGEOLOGIC DATA ANALYSIS GOALS

The chemical data collected prior to and during the operation of the E/R and E Units will be analyzed to address the following design issues, as listed below.

A. ***Effective Full-Scale Groundwater Characterization:*** The geophysical profiles will be produced during the characterization of the Pilot Project study area. The comparison of these profiles with monitoring well nest data will determine the applicability of the use of the geophysical methods for the full-scale, vertical characterization of the groundwater zone, which has been targeted for cell-based extraction and re-injection remedy (Figure 1.2). The combination of such field tests along with focused groundwater sample analyses can provide an effective alternative for groundwater quality characterization of the targeted zone.

B. ***Removal Rate/Concentration Decay in E/R Unit:*** Time series plots of collected groundwater quality data at various depths and locations, as well as extracted water measured concentrations, will be analyzed to estimate the contaminant mass removal, concentration decay rates, and removal limitations under full-scale operation. This analysis will be used to establish groundwater extraction termination criteria.

C. ***Impacts of Re-injection:*** Through comparison of the time series groundwater quality data collected at the E/R and E Units, the impact of re-injected water will be assessed. The re-injected water may enhance the restoration of the groundwater. Specifically:

- The flushing/sweeping effects of the re-injected water could increase the effectiveness of the inner extraction wells in the removal of contaminants.
- The re-injection of the treated water could reduce concentrations of attenuation inhibitors, and thus, enhance the rate of in-situ natural attenuation of groundwater contaminants.

- The chemical characteristics of the re-injected water, such as higher oxygen and nitrogen contents, could further accelerate the natural attenuation of groundwater contaminants.
- The re-injection of water could also cause local dispersion of groundwater contaminants toward the upper portion of the shallow aquifer. As supported by site-specific data (e.g., Figures 1.3 and 1.4), such dispersions may yield a more rapid degradation of contaminants in the upper portion of the shallow aquifer.

Over time, however, the dilution caused by re-injection of treated water can gradually reduce the mass removal efficiency of an extraction unit. In other words, re-injection may gradually reduce the mass of contaminants per unit volume of extracted water.

Comparison of the E/R and E Units removal performance will provide information on appropriate re-injection schemes. The intent is to increase the positive effects of re-injection, while minimizing effects of gradual removal efficiency decreases. The analysis will consist of the following:

- Comparison of the mass removal rates over time between the E/R and E Units will determine if removal efficiencies increase or decrease significantly as re-injected water reaches the extraction wells. The results of the bromide tracer testing will be utilized to estimate re-injection water travel times.
- Comparison of the water quality variation and bromide tracer testing results within different zones of the shallow aquifer will be utilized to determine the vertical and horizontal transport of contaminants of concern.

D. Impact of Extraction Rate: The comparison of the E/R and E Units contaminant removal performance will provide information for determining an appropriate extraction rate within the low-flow range of approximately 0.8 to 0.2 gpm per well. The analysis will consist of comparing mass removal to groundwater removal volumes and estimating the time periods required to reach various target in-situ contaminant concentrations.

E. Impact of Cyclic versus Continuous Extraction: The data on performance of the continuously operated E/R Unit versus the intermittently-operated E Unit will provide information on assessing the impact of cyclic and continuous extraction on the removal efficiency of an extraction/re-injection system. As with the analysis of extraction rates, the focus of this analysis will be on mass removal relative to groundwater removal volumes and estimation of time periods required to reach various target in-situ contaminant concentrations.

F. ***Effects of Sorption/Desorption:*** Finally, the data during the intermittent operation of the E Unit and the post-extraction sampling will provide information for estimating the effects of sorption, desorption, and transport of various groundwater contaminants on the overall removal efficiency of an extraction/re-injection system. This analysis will assist in establishing criteria for cycling of groundwater extraction as well as criteria for termination of extraction within a given cell.

7.2 TREATMENT ASSESSMENT DATA ANALYSIS GOALS

The bench-scale groundwater treatment testing data will be used to accomplish three goals, as described below.

A. ***Contaminant-specific Removal Efficiency:*** The first goal is to determine the design removal efficiency for phenol, cyanide, and thiocyanate and the nitrification efficiency. The three sets of data collected at the end of the acclimation phase of testing will be used to perform mass balances on the SBRs for each of these compounds. Computed mass balances will be used to calculate the removal efficiencies for each of the compounds of interest.

B. ***Selected Approach for Phenol Degradation and Nitrification:*** The second goal is to select the approach for achieving phenol degradation and nitrification. Both the removal efficiencies and the kinetic data for the SBR-1 and SBR-2 treatment train and SBR-3 will be compared in order to evaluate the merits of each approach for removing the contaminants of concern from the contaminated groundwater.

C. ***Design Parameters:*** The third goal is to determine the kinetic parameters to be used in design of the full-scale groundwater treatment system. Data from the batch test will be utilized to calculate the stoichiometric and reaction rate coefficients for the degradation of each contaminant of concern. These coefficients will then be used to develop kinetic models to be used in the full-scale design.

7.3 DATA ANALYSIS DECISIONS

The results of the Pilot Project data analyses will be used to make design decisions, including:

A. ***Spatial Configuration of Mobile Cells:*** This would include the vertical and horizontal configuration of the extraction and re-injection wells within each full-scale E/R cell.

B. ***Effective E/R Rates:*** An effective extraction and re-injection rate and schedule that enhances the removal efficiency of the E/R cell, while minimizing the adverse effects of the re-injection process, will be determined.

C. ***Simultaneous and Sequential E/R Cell Grouping:*** Based on the Pilot Project data analysis, effective operation strategies for mass removal, treatment, and re-injection will be determined. The operating programs may include simultaneous E/R cell operations, as well as sequential operation of groups of cell in order to maintain the consistency of the treatment unit influent chemical properties. Furthermore, to balance the positive and adverse effects of re-injection on the overall mass removal efficiency, various extraction and re-injection patterns will be evaluated. These patterns may include simultaneous (i.e., same-cell) extraction and re-injection, or offset extraction and re-injection schedules.

D. ***Cell Performance Standards Verification:*** Based on the collected data, appropriate performance standards and goals for cell operation will be developed. These targets include performance standards based on concentration or mass removal of contaminants at the base of the shallow aquifer, extraction volumes, and/or attainment of natural attenuation threshold levels[5], if applicable, subject to site-specific hydrogeologic and treatment constraints. The monitoring plan of each E/R cell, including termination rules and procedures, will also be developed as part of the verification process.

[5] Concentrations of natural attenuation inhibitors beyond which ROD long-term remedial objectives can be achieved through natural attenuation processes.

E. ***Treatment System Components:*** The treatability data results will be used to determine various components of the future onsite treatment unit. The selected treatment trains will focus on: (1) achieving treatment mass removal, (2) creating conditions leading to the attainment of natural attenuation threshold levels at the base of the shallow aquifer, if applicable, and (3) benefiting from potential benefits of added nitrate and oxygen.

F. ***Treatment Performance Standards Verification:*** Treatment performance standards and goals will be developed based on effluent concentrations, mass removal, and/or attainment of natural attenuation threshold levels at the base of the shallow aquifer, if applicable, subject to hydrogeological and treatment constraints.

8.0 PILOT PROJECT REPORT OUTLINE

The results of the Pilot Project will be documented in a report, which will be submitted to U.S. Environmental Protection Agency (EPA) and Illinois Environmental Protection Agency (IEPA) for review and comment. This report will address the following topics:

1. Description of Pilot Project components and analytical results;
2. E/R cell configuration, including: well configuration, depth, and E/R rates and schedule;
3. Performance standards for E/R cell operation, based on in-situ concentrations, mass removals, extraction volumes, or attainment of natural attenuation threshold levels, subject to hydrogeologic and treatment constraints;
4. Performance standards for treatment unit operation, based on effluent concentration, mass removal, or in-situ attainment of natural attenuation threshold levels, subject to hydrogeologic and treatment constraints; and
5. Performance standard measurement for both cells and treatment unit operation, including monitoring plans, as well as termination rules and procedures.

9.0 PILOT PROJECT SCHEDULE

Upon submittal and approval of this Pilot Project Work Plan the following phases must be implemented:

1. Preparation of Plans, Field Construction Drawings, Treatability Test Protocol, Quality Assurance Project Plan (QAPP), and Sampling Analysis Plan (SAP)
2. Contractor Procurement and Mobilization
3. Installation of Pilot Units and Equalization Tanks
4. Pilot Unit Operations
5. Follow-up Laboratory Treatability Testing of Equalized Extracted Water
6. Pilot Testing and Treatability Study Data Compilation
7. Preparation of Pilot Report

The Pilot Project anticipated schedule table is shown in Figure 9.1.

10.0 REFERENCES

Barr Engineering Company, 1995. Remedial Investigation Report, *Waukegan Manufactured Gas and Coke Plant Site, Waukegan, Illinois*.

Barr, 1998. *Feasibility Study, Waukegan Manufactured Gas and Coke Plant Site, Waukegan, Illinois*.

Table 5.1 E/R and E Units Operation Plan

Pilot Unit	Pumping Rate (gpm)							
	Week in Test							
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
E/R	0.9	0.9	0.9	0.9				
E	0.8		0.6		0.4		0.2	

Table 5.2 Groundwater Sampling and Analysis Plan

Cell	Test	Monitoring Well Nest	Sampling Frequency	Number of Events	Locations Sampled	Vertical Points/ Location	Samples per Event	Total Samples	Analysis																
									Total Phenol	As	Ammonia	Bromide	VOC	GC/MS (Base/ Neutral)	GC/MS (Acid)	Nitrate	Iron	Microtox	COD	Cyanide	Thiocyanate	Alkalinity	TSS
E/R Cell	Contaminant mass removal determination	1	daily	7	1	5	5	35	35	35	35												
		1	3Xweek	9	1	5	5	45	45	45	45												
		2	3Xweek	12	1	5	5	60	60	60	60												
		1 & 2	weekly	4	2	5	10	40					40	40	40					40	40		
		1 & 2	start/stop	2	2	5	10	20	20	20	20		20	20	20					20	20		
	Subtotal			34	7	25	35	200	160	160	160	0	60	60	60	0	0	0	0	60	60	0	0
	Tracer Test		daily	14	1	5	5	70				70											
			3xweek	6	1	5	5	30				30											
	Subtotal			20	2	10	10	100				100											
	Extracted water		3xweek	12	3	1	3	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36
	Subtotal			12	3	1	3	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36
E Cell	Contaminant mass removal determination	3	3Xweek	12	1	5	5	60	60	60	60												
		3	weekly	4	1	5	5	20					40	40	40					40	40		
		3	start/stop	2	1	5	5	10	10	10	10		10	10	10					10	10		
	Subtotal			18	3	15	15	90	70	70	70	0	50	50	50	0	0	0	0	50	50	0	0
	Extracted water		3xweek	12	1	1	1	12	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36
	Subtotal			12	1	1	1	12	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36
Post-Extraction	Contaminant recovery determination (E Wells)		Twice:one-week after, and one-month after	2	4	1	4	8	8	8	8		8	8	8					8	8		
Total								446	310	310	310	172	190	190	190	72	72	72	72	190	190	72	72

Table 6.1 Initial SBR Operating Strategy

Period	Duration (hours)
Aerated FILL	2
Aerated REACT	2.5
SETTLE	1
DRAW	0.5

Table 6.2 Initial SBR Operating Parameters

SBR	Hydraulic Retention Time (days)	Solids Retention Time (days)	Average Dissolved Oxygen (mg/L)	Mixed Liquor Suspended Solids (mg/L)
1	5	10 - 20	> 2	2000 - 3000
2	5	20 - 30	> 2	3000 - 5000
3	5	20 - 30	> 2	3000 - 5000

Table 6.3 Sampling and Analyses for Acclimation Monitoring

Sample Location	Time of Sample	Analyses				
		COD	Total Phenol	NH_3-N	MLVSS	pH
Feed Container	FILL	X	X	X		X
SBR Bulk Liquid	REACT				X	X
	DRAW	X	X	X		

COD - chemical oxygen demand

MLVSS - mixed liquor volatile suspended solids

Table 6.4 Samples and Analyses for Performance Verification

Sample Location	Time of Sample	COD	Total Phenol	Microtox	TKN	NH_3-N	NO_3-N	VOC	GC/MS (Base/Neutral)	GC/MS (Acid)	Cyanide	Thiocyanate	pH
		Analyses											
Feed Container	FILL	X	X	X	X	X	X	X	X	X	X	X	X
SBR Bulk Liquid	Before FILL	X	X	X	X	X	X	X	X	X	X	X	X
	DRAW	X	X	X	X	X	X	X	X	X	X	X	X

COD - chemical oxygen demand

TKN - total kjeldahl nitrogen

Table 6.5 Samples and Analyses for Batch Time Study

Sample Location	Time of Sample	Analyses												
		COD	Total Phenol	Microtox	TKN	NH_3-N	NO_3-N	VOC	GC/MS (Base/Neutral)	GC/MS (Acid)	Cyanide	Thiocyanate	Dissolved Oxygen	pH
SBR Bulk Liquid	After FILL	X	X	X	X	X	X	X	X	X	X	X		X
	Every 30 min.	X	X	X	X	X	X	X	X	X	X	X	X	X

COD - chemical oxygen demand

TKN - total kjeldahl nitrogen

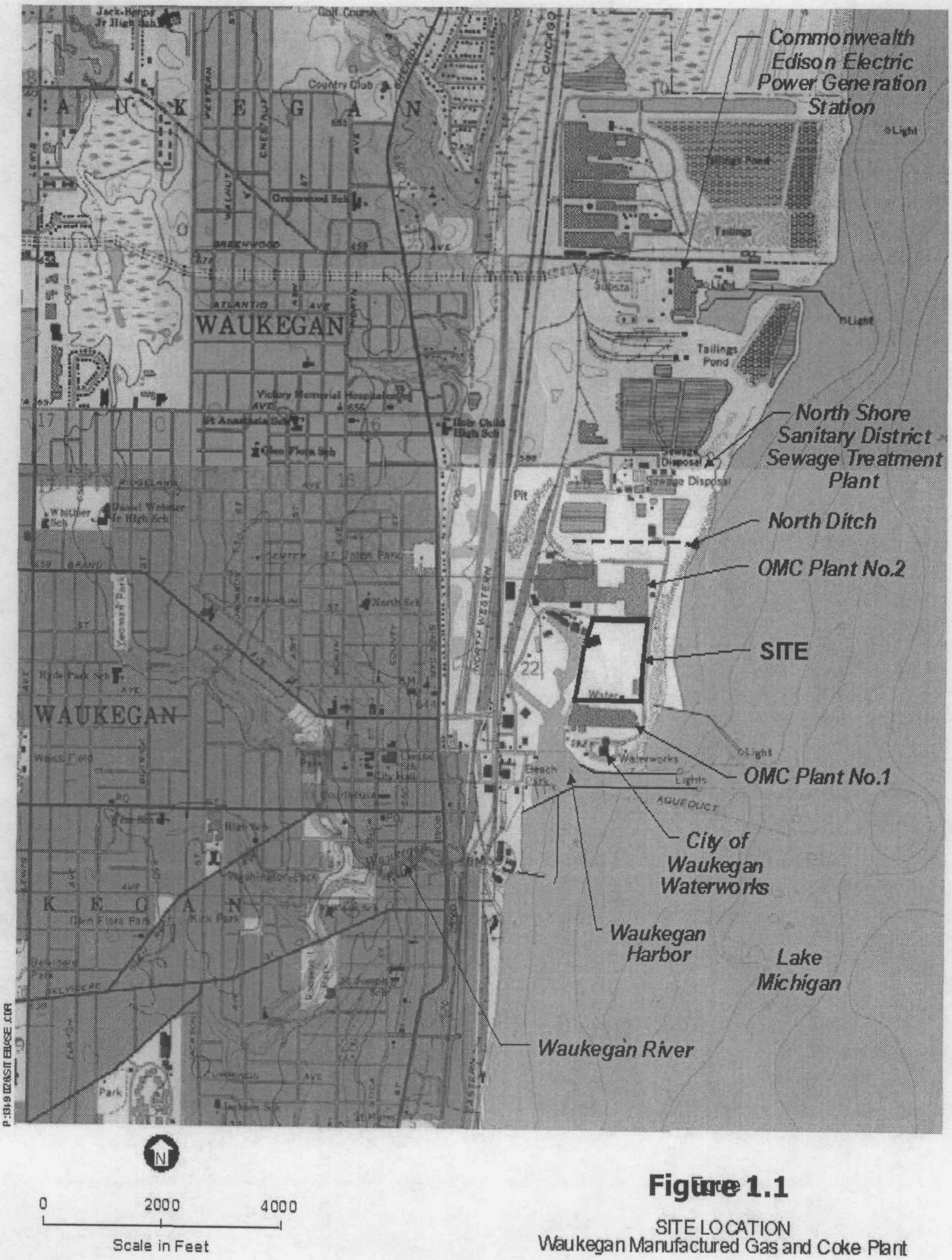


Figure 1.1

SITE LOCATION
Waukegan Manufactured Gas and Coke Plant

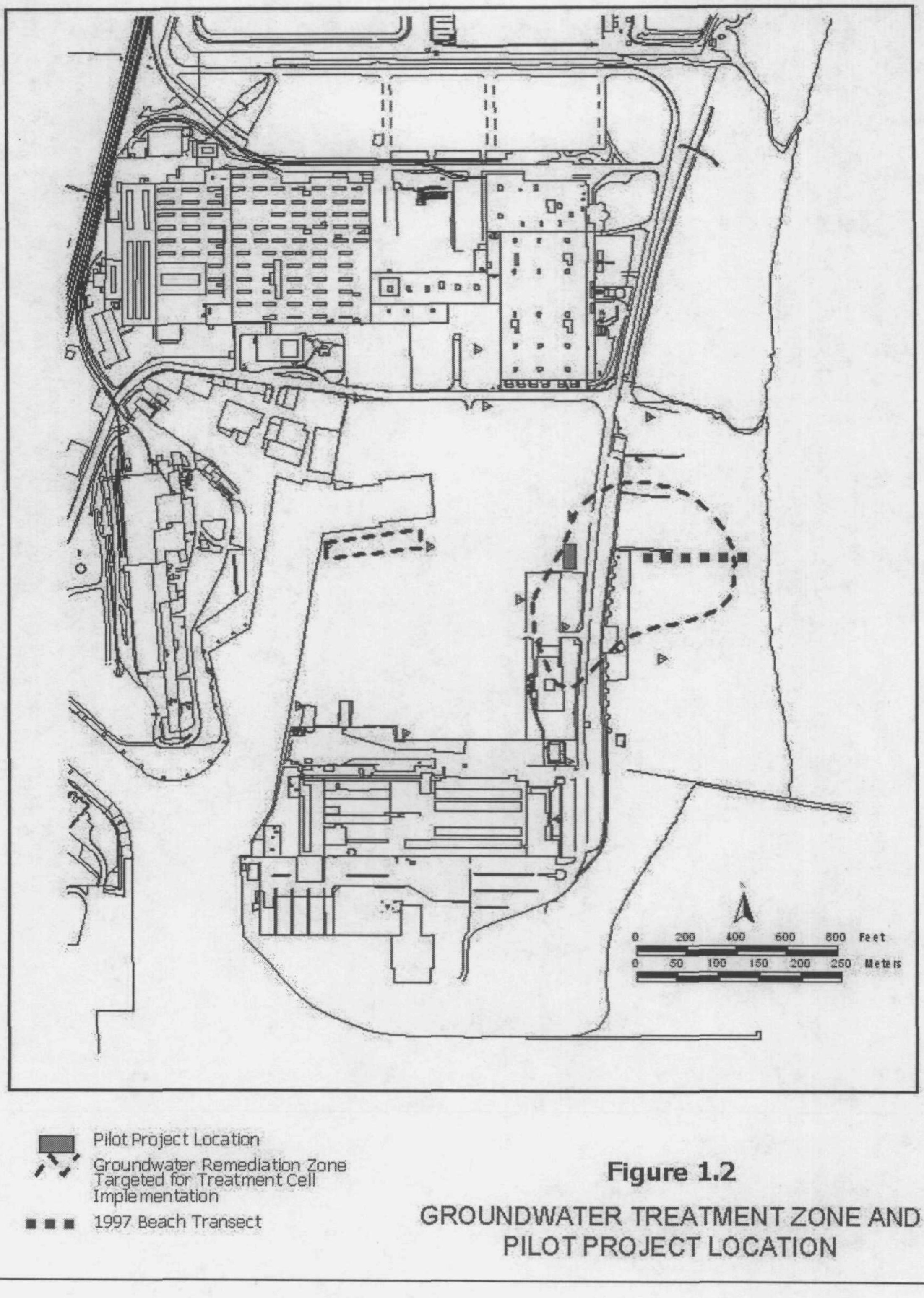


Figure 1.2

GROUNDWATER TREATMENT ZONE AND PILOT PROJECT LOCATION

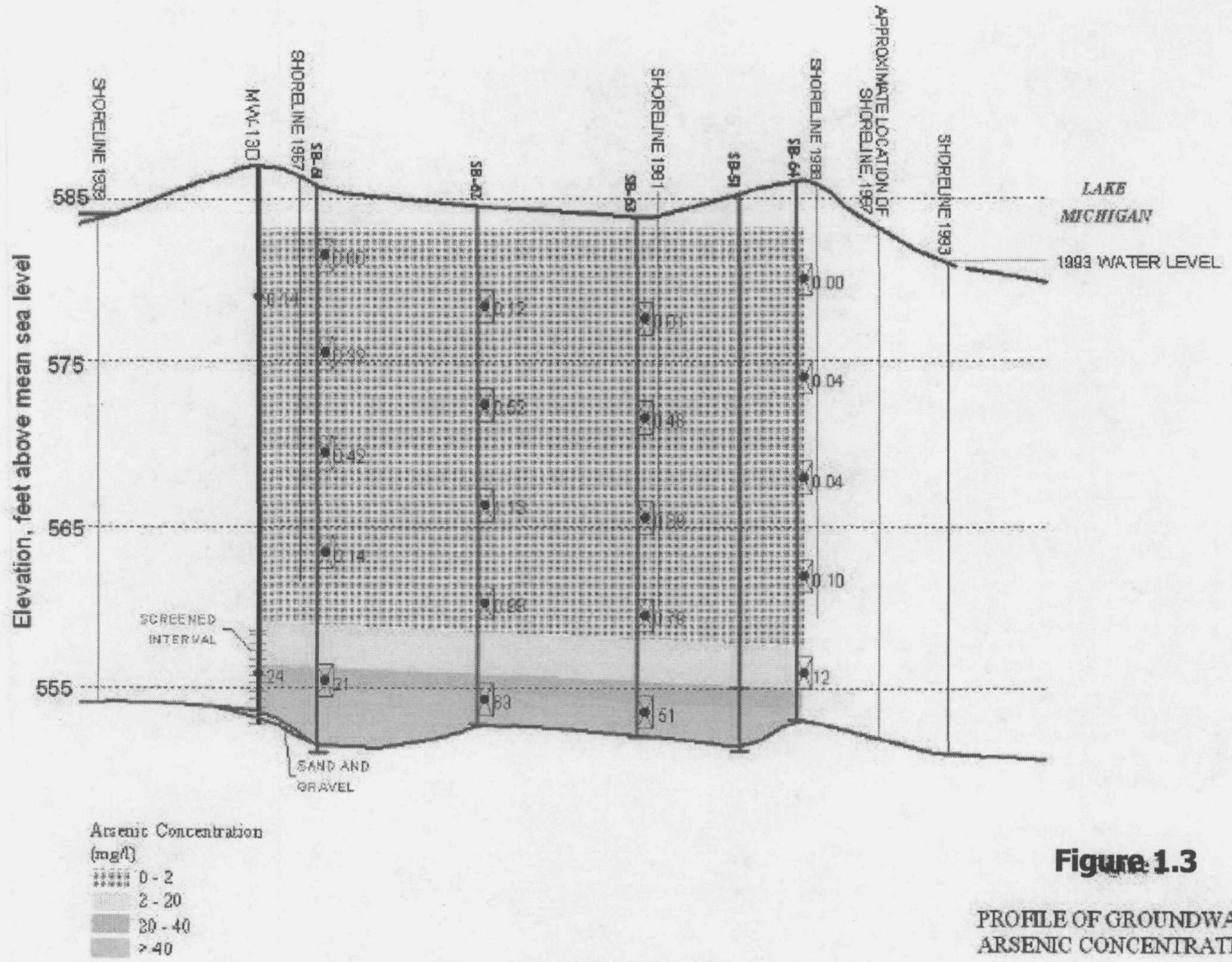


Figure 1.3

PROFILE OF GROUNDWATER ARSENIC CONCENTRATIONS

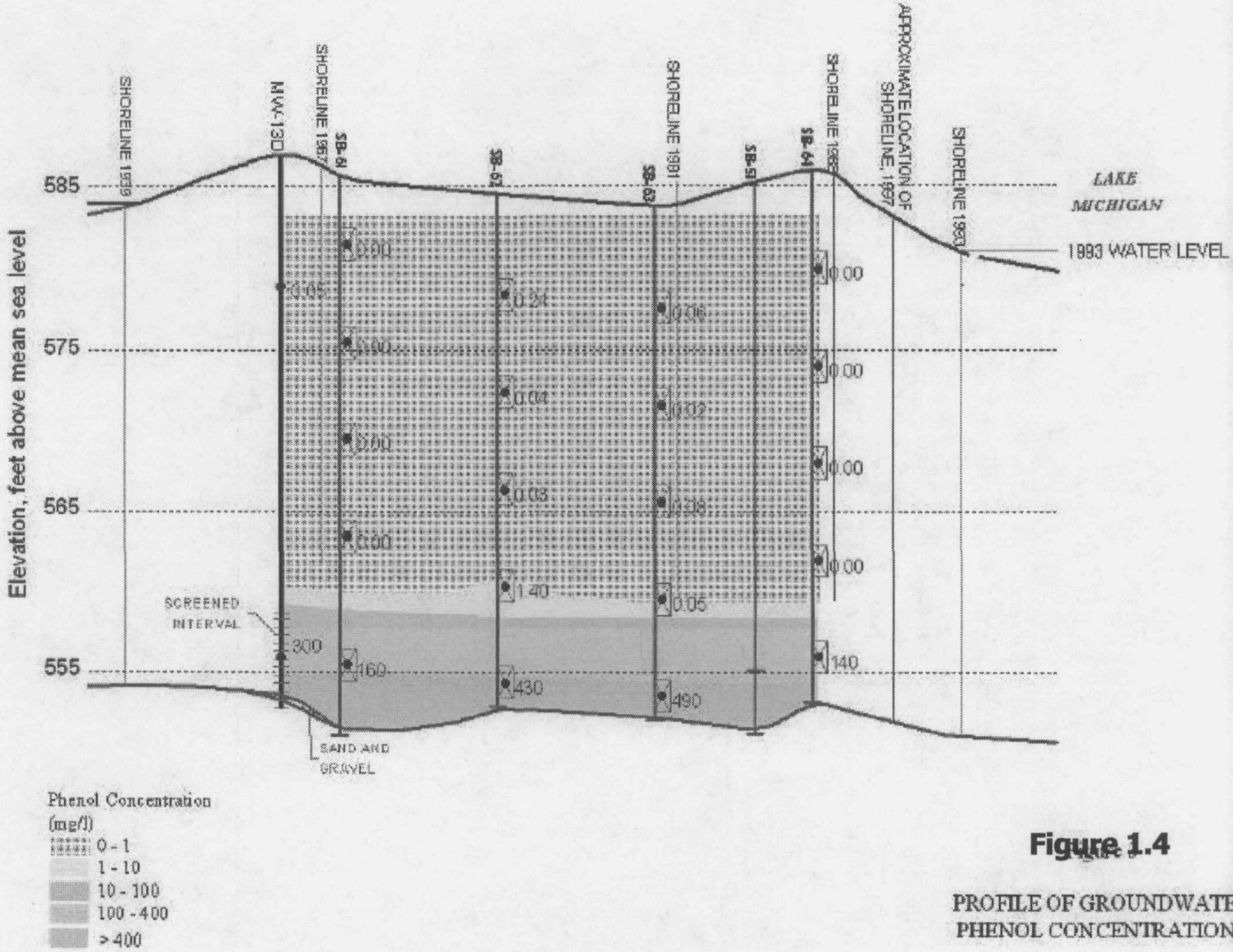


Figure 1.4

PROFILE OF GROUNDWATER
PHENOL CONCENTRATIONS

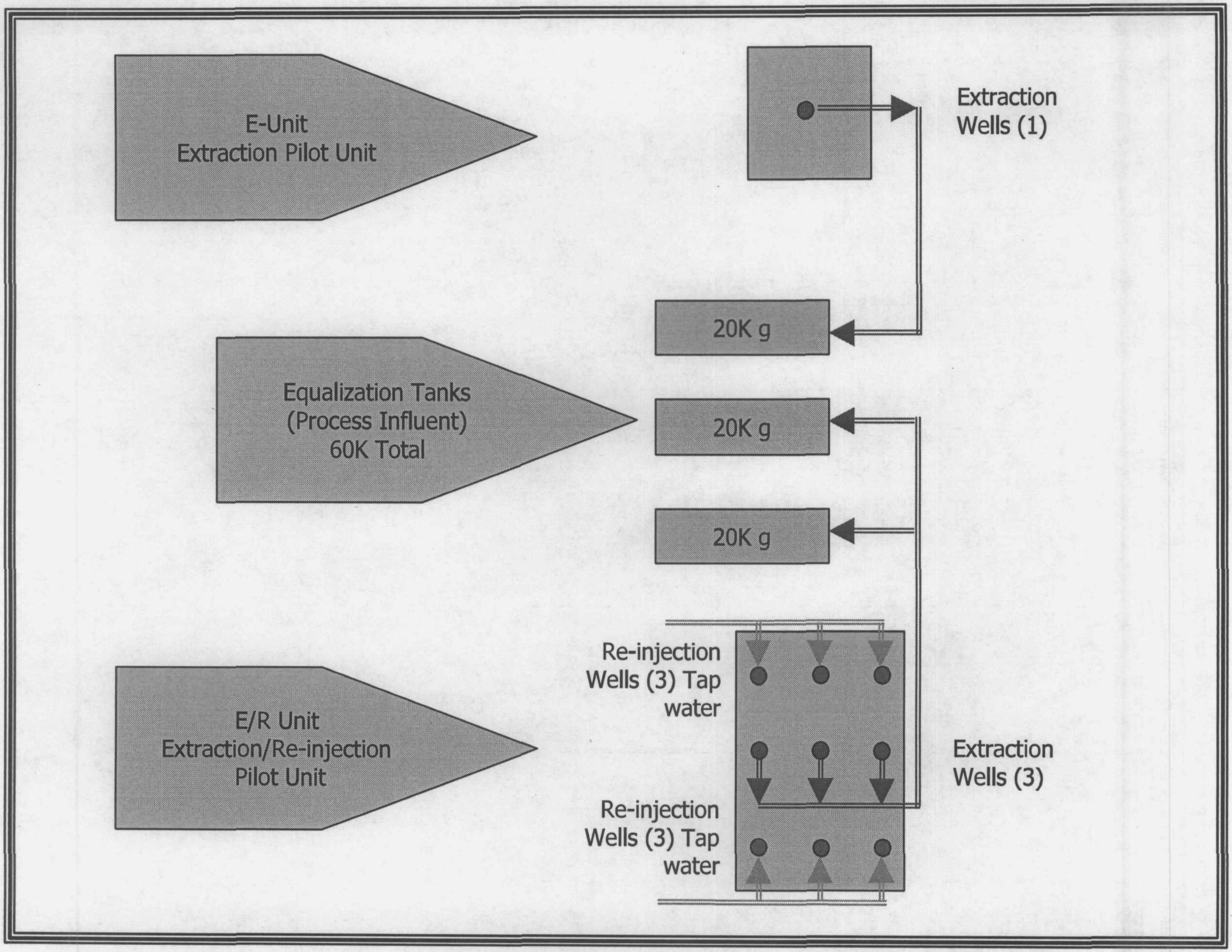


Figure 3.1

Pilot Project Conceptual Configuration

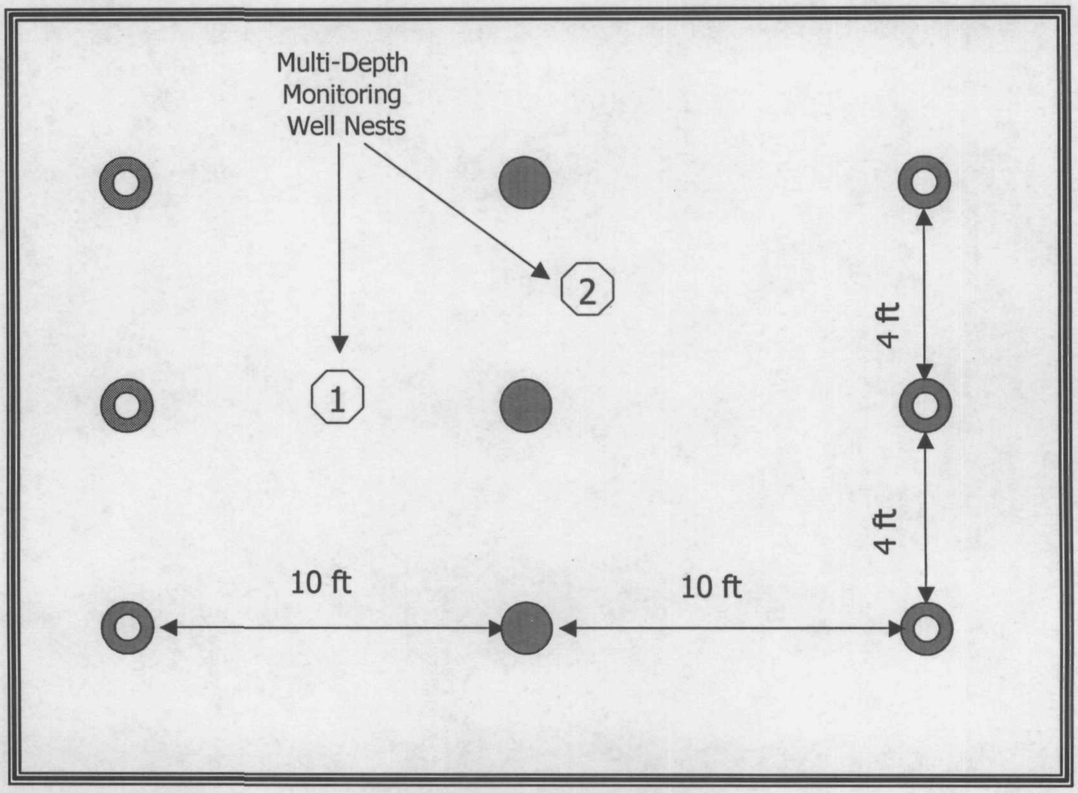
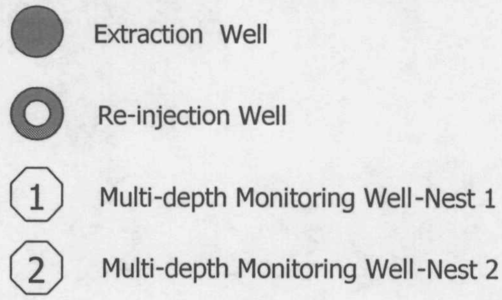


Figure 5.1 E/R Unit Plan View



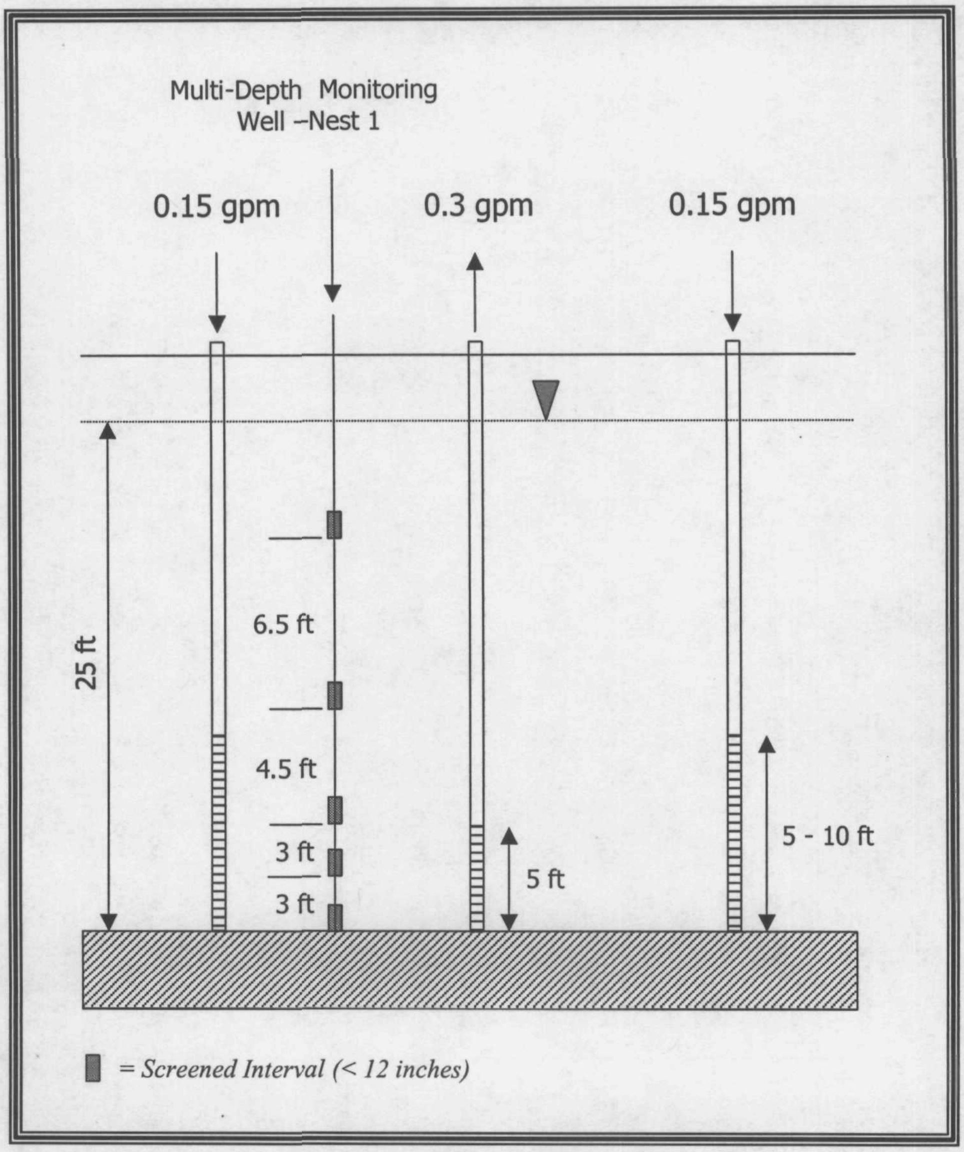


Figure 5.2 E/R Unit Cross Section

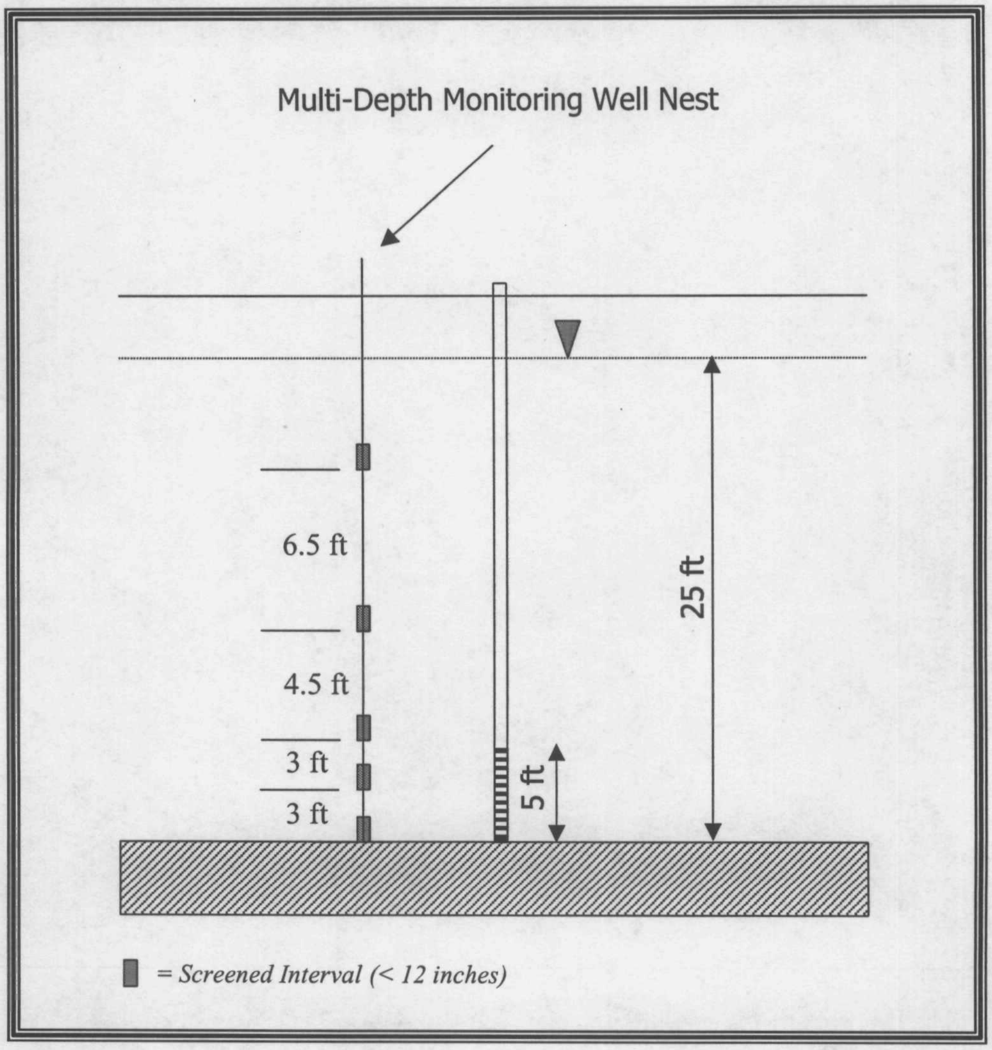
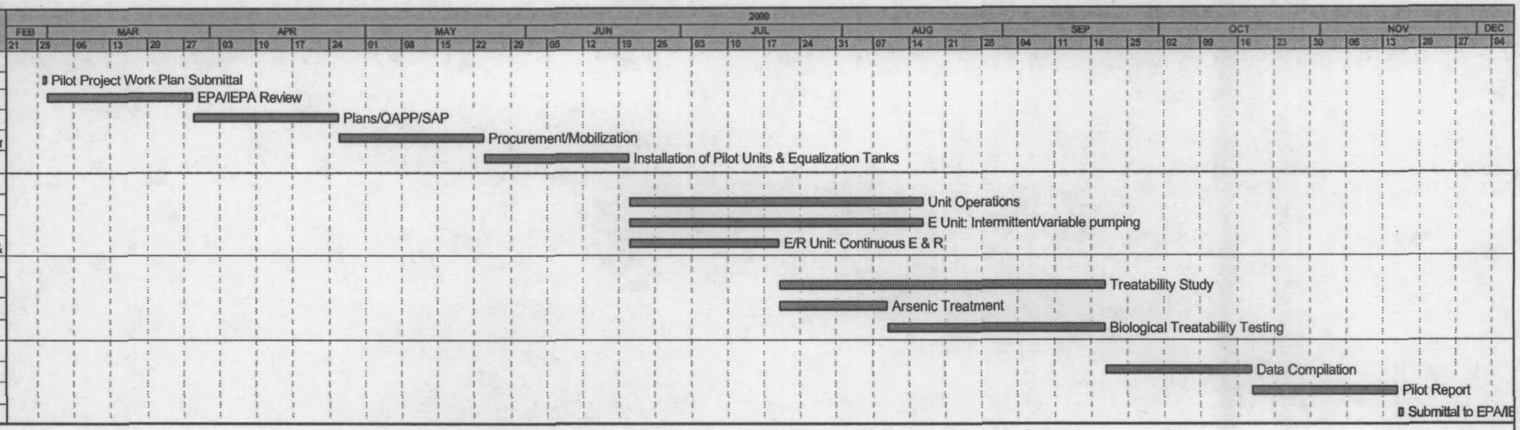


Figure 5.3 Multi-Depth Monitoring Well Nest in E Unit

Orig Dur	Rem Dur	Early Start	Early Finish	Description
1	1	29FEB00	29FEB00	Pilot Project Work Plan
20	20	01MAR00	28MAR00	EPA/IEPA Review
20	20	29MAR00	25APR00	Plans/QAPP/SAP
20	20	26APR00	23MAY00	Procurement/Mobilizatior
20	20	24MAY00	20JUN00	Installation of Pilot Units
40	40	21JUN00 *	16AUG00	Unit Operations
40	40	21JUN00	16AUG00	E Unit
20	20	21JUN00	19JUL00	E/R Unit: Continuous E &
45	45	20JUL00	20SEP00	Treatability Study
15	15	20JUL00 *	09AUG00	Arsenic Treatment
30	30	10AUG00 *	20SEP00	Biological Treatability
20	20	21SEP00	18OCT00	Data Compilation
20	20	19OCT00	15NOV00	Pilot Report
1	1	16NOV00	16NOV00	Submittal to EPA/IEPA



Start date	29FEB00
Finish date	16NOV00
Data date	29FEB00
Run date	23FEB00
Page number	1A

Figure 9.1
Waukegan Pilot Project Work Plan